

- 1 -

SOLVENTLESS UNIVERSAL COLORANTS

FIELD OF THE INVENTION

5 This invention relates to solventless universal colorants that can be easily letdown in both water and solvent-based dispersions/inks without additional grinding.

BACKGROUND OF THE INVENTION

10 Printing ink manufacturers produce many surface and laminating flexographic or gravure inks. They are made either by grinding the dry pigments/presscakes into the vehicles, or letting down the waterborne or solventborne bases with appropriate technology varnishes. In the first case, after being mixed into aqueous or solvent-based vehicles in the process of making bases or inks, 15 the dry pigments or presscakes must be further dispersed by grinding. This grinding step generally requires that the pigments be ground for a period of hours using milling equipment, such as a ball mill or an attritor mill. In the second case, a substantial inventory of 20 different bases is required for making different inks. It is thus a great advantage to develop "Solventless Universal Bases" that can be easily letdown into either waterborne or solventborne dispersions/inks without additional grinding. This not only reduces the costly 25 and time-consuming grinding process, but also reduces the inventory cost by using one base for multi-ink systems. Because the solventless base is already well dispersed, the cost may be further reduced by eliminating bad

grinding batches and reworks. The freeze/thaw stability problem can also be eliminated due to the solventless nature of the bases. Additionally, the shelf life of the solventless bases is extended dramatically compared to  
5 the liquid bases.

Several U.S. Patents (U.S. Patent Nos. 5,084,573, 5,095,122, 5,298,076, and 5,347,014) described a number of "effect Pigments" that are stir-in pigments which can be added to a coating or ink system without additional grinding. "Effect pigments" are described as inorganic or organic pigments that show metallic, pearlescent and/or silky-luster effects. These patents, however, did not disclose the "non-effect pigments" such as the yellow, magenta, cyan, black process colors. Two other  
10 U.S. Patents (U.S. Patent Nos. 5,554,217 and 5,648,408) described the use of stir-in pigments in the suspension or solution of high molecular weight organic material (coatings or inks). The stir-in pigments were prepared by the wet-milling process and contain organic pigments, inorganic fillers and additives such as texture-improving agents. The stir-in pigments in these two patents were intended for use in organic systems instead of water-based systems. None of them is prepared by a hot melt dispersion process. Commercially available solventless  
15 bases or pigment chips are based on acrylics, SMA and nitrocellulose (Product Brochures of Knight Colors, KVK USA, Penn Colors, RHB Dispersions). None of these commercially available pigment chips can be used in both solvent and water-based systems. None of the patents or  
20  
25

literature disclosed the effect of resin hydrophilicity and hydrophobicity balance on the performance of solventless colorants. In addition, the preferred resins disclosed in this invention record provide dramatically improved pigment dispersion characteristics and improve the overall pigment efficiency. Compared to other resins, the preferred resins permit manufacturing of inks or coatings at lower pigment content but with improved color characteristics.

#### SUMMARY OF THE INVENTION

The present invention provides a method of preparing a universal base composition comprising dispersing a pigment in a resin that is soluble in both water and organic solvent and wherein: (a) said resin comprises both hydrophobic and hydrophilic monomers; (b) the total weight of the hydrophobic and hydrophilic monomers is at least about 20% of the total weight of the resin; and (c) the weight ratio of hydrophobic monomers to hydrophilic monomers is from about 1/5 to about 5.

The present invention also provides a universal base composition comprising a pigment and a resin that is soluble in both water and organic solvent, wherein: (a) said resin comprises both hydrophobic and hydrophilic monomers; (b) the total weight of the hydrophobic and hydrophilic monomers is at least about 20% of the total weight of the resin; and (c) the weight ratio of hydrophobic monomers to hydrophilic monomers is from about 1/5 to about 5.

Other objects and advantages of the present invention will become apparent from the following description and appended claims.

**DETAILED DESCRIPTION OF THE INVENTION**

5           It has now been found that a universal base composition is prepared by dispersing a pigment in a resin that is soluble in both water and organic solvent and wherein the resin contains both hydrophobic and hydrophilic monomers such that the total weight of the  
10           hydrophobic and hydrophilic monomers is at least about 20% of the total weight of the resin and the weight ratio of hydrophobic monomers to hydrophilic monomers is from about 1/5 to about 5.

15           A universal base composition is defined for the purpose of this invention as a composition containing a pigment and a resin that can be easily letdown into solvent or waterborne dispersions/inks without additional grinding.

20           A Hydrophilic monomer is defined for the purpose of this invention as a monomer that, after being made into a polymer, contains at least one functional group that impart the solubility in both water and solvent (lower alcohol and lower alcohol/acetate mixtures). Such functional groups include but are not limited to -COOH, -  
25           OH, -PEO, -NH<sub>2</sub>, -SO<sub>3</sub>H, piperazine, pyrrolidone.

Examples of hydrophilic monomers include but are not

limited to 2,2-dimethylol propionic acid; trimethylol  
propane; 2,2-dimethylol-1,3-propanediol; acrylic acid;  
triethylene glycol; glycerol; pentaerythritol; 2,2-  
dimethylol butanoic acid; methacrylic acid; trimellitic  
5 anhydride; methyl hydroxylacrylate; ethyleneglycol  
monomethacrylate; piperazine; maleic anhydride; vinyl  
alcohol; and vinyl pyrrolidone

Hydrophobic monomer is defined for the purpose of this  
invention as a monomer that contains paraffinic chain with  
10 at least six carbon atoms, or contains hydrocarbon ring  
with at least 8 carbon atoms. Furthermore, a hydrophobic  
monomer, after being made into a polymer, does not contain  
the functional groups that impart solubility in both water  
and solvent (lower alcohol and lower alcohol/acetate  
15 mixtures).

Examples of hydrophobic monomers include but are not  
limited to tetrahydrophthalic anhydride; dimer diol;  
styrene; -methyl styrene; isophoronediamine; dimer acid;  
diphenylmethane-4,4'-diisocyanate; bisphenol A; 1,6-  
20 hexanediol; sebacic acid; azelaic acid; stearic acid;  
octanoic acid; hexamethylene diamine; isobornyl  
methacrylate; and 2-methyl-1,5-pentanediamine

The inks based on these universal base compositions  
can be printed by flexo and gravure processes, for surface  
25 or laminating application. The inks based on these  
universal base compositions can also be used as jet inks  
due to their extremely fine particle size and excellent

stability of the pigment particles.

Essential components of the universal base composition in the present invention are resins that have good solubility in both water and solvent (alcohol/ester). Typical resins in this invention have either acid or amine functionality for good solubility in both water and solvents. Acid values of the typical resins in this invention range from about 0 to about 300, preferably about 30 to about 250. Amine values of the typical resins (polyamide, e.g.) in this invention range from about 0 to about 400, preferably about 150 to about 380. The softening point of the resins can range from 20°C to 200°C. The molecular weight of the resin typically ranges from 500 to 1,000,000.

The resins should also possess appropriate hydrophilicity and hydrophobicity balance (HLB) to be effective pigment dispersants. Hydrophobic groups adsorb onto the pigment surface as anchors (adsorption property), while hydrophilic groups are solvated in water or alcohol/acetate and stabilize pigment particles by either steric or electrostatic stabilization. Both the hydrophobic and hydrophilic groups are important for particle stabilization and an appropriate HLB can result in good solubility, rheological and optical properties. If either the adsorption property or steric/electrostatic repulsion force is not sufficient, the solventless colorants may not be soluble in desired solvent(s). At intermediate levels of adsorption property and

steric/electrostatic repulsion force, the pigment particles can become flocculated and bridged, resulting in a more thixotropic dispersion which is manifested by weaker color strength.

5           Resins with the above properties include, but are not limited to, polyesters, acrylics, polyurethanes, polyamides and copolymers such as urethane-amides, urethane-esters.

10           The universal base compositions can be prepared using a hot melt grinding process, which involves grinding pigments or presscakes in softened or molten resins under a high shearing force, with or without additives. Upon cooling, the universal base composition can be obtained. The hot melt grinding processes include, but are not  
15           limited to, sigma-blade mixing (Brabender, Baker Perkins, e.g.) and single-screw or twin-screw extrusion. The universal base composition may also be prepared by grinding the pigments/presscakes in the presence of resin/solvents, then driving off the solvents.

20

          The resultant solventless universal base composition can be letdown into: 1) water or solvent-based dispersions with water (ammonical water, if necessary) or solvent; 2) water or solvent-based inks with water or solvent-based  
25           technology varnishes; 3) water or solvent-based inks with water or solvent alone. The letdown process involves only low-energy mixing. No additional pigment grinding is required. The inks and dispersions possess ultra-fine particle size, narrow particle size distribution, and

possess superior color strength, gloss and transparency characteristics compared to conventionally prepared dispersions/inks. The inks can be printed with flexographic, gravure or ink jet processes, for either surface or laminating application. The performance of the inks can be modified by the addition of suitable technology varnishes (resins/additives/solvents) in order to meet the requirements of the end use applications.

**Example 1: Preparation of Universal Base Compositions**

**I) Solventless Universal Base Composition 1 (UB1):**

UB1 is composed of the following:

50 g Phthalo blue pigment 15:4

(Daicolor Pope)

50 g Polyamide resin(Amine #: 360, MW<sub>w</sub>: 3500,

Softening point: 30°C)

(Piperazine (Huntsman Chemical)/Ethyl Acrylate

(Rohm & Haas)/Dytec A (Dupont), Molar ratio:

1/2/1)

The above polyamide resin (50 g) is added into the steam-heated Brabender (100°C) and mixed at low speed (~20RPM) until all the resin was melted. The Blue pigment 15:4 (50 g) is then slowly added in a period of 30 minutes while mixing. The mixing at 100RPM is continued for another two hours after which the solventless composition is discharged and cooled down. The universal base composition in powder-form is then obtained by grinding with an Osterizer.



II) Universal Base Composition 2 (UB2):

UB2 is composed of the following:

50 g Phthalo blue pigment 15:4

(Daicolor Pope)

5 50 g Polyester (Acid #: 80, MW<sub>w</sub>: 5000, Softening  
point: 85°C)

(Trimethylol Propane (Perstorp)/2,2-Dimethylol  
Propionic acid (Trimet Technical Product)/  
Tetrahydrophthalic Anhydride (Lonza), Molar  
10 ratio: 4.9/1.0/4.2)

The above polyester resin (50 g) is added into the  
steam-heated Brabender (100°C) and mixed at low speed  
(~20RPM) until all the resin was melted. The Blue pigment  
15:4 (50 g) is then added slowly in a period of 30 minutes  
15 while mixing. The mixing at 100RPM is continued for  
another two hours after which the solventless composition is  
discharged and cooled down. The universal base composition  
in powder-form is then obtained by grinding with an  
Osterizer.

20 III) Universal Base Composition 3 (UB3):

UB3 is composed of the following:

50 g Phthalo blue pigment 15:4

(Sun Chemical Color Group)

25 50 g Polyurethane (Acid #: 69, MW<sub>w</sub>: 5800, Softening  
point: 120°C)

(Toluene Diisocyanate (Bayer)/2,2-Dimethylol  
Butanoic acid (Mitsubishi)/Dimer Diol 1075  
(Henkel)/2-methyl-1,3-propanediol (Arco), Molar  
ratio: 0.95/0.36/0.07/0.42)

The above polyurethane resin (50 g) and pigment 15:4 (50 g) are mixed together. At 200RPM, the mixture is passed through a twin screw extruder which is preset at 260°F. The product is then cooled down. The universal  
5 base composition in powder-form is then obtained by grinding with an Osterizer.

IV) Universal Base Composition 4 (UB4):

UB4 is composed of the following:

50 g Phthalo blue pigment 15:4  
10 40 g Acrylics (Acid #: 238, MW<sub>w</sub>: 1700, Softening  
point: 105°C)  
(Joncryn 683, S.C. Johnson)  
10 g Propylene Glycol

15 The above acrylics resin (40 g) is added into the  
steam-heated Brabender at 110°C. It is then mixed at low  
speed (~20RPM) while slowly adding propylene glycol (10 g)  
until all the resin was melted. Then, the Blue pigment  
15:4 (50 g) is slowly added in a period of 30 minutes while  
20 mixing. The mixing is continued at 100RPM for another two  
hours after which the resulting solventless composition is  
cooled down. The universal base composition in powder-form  
is then obtained by grinding with an Osterizer.

V) Universal Base Composition 5 (UB5):

UB5 is composed of the following:

- 157 g      Phthalo blue pigment 15:4 presscake (35%  
solid)  
5            (Sun Chemical Color Group)  
45 g      Polyurethane (Acid #: 42, MW<sub>w</sub>: 6000,  
Softening point: 120°C)  
(Toluene Diisocyanate (Bayer)/2,2-Dimethylol  
Butanoic acid (Mitsubishi)/Dimer Diol 1075  
10           (Henkel)/2-methyl-1,3-propanediol (Arco),  
Molar ratio: 0.95/0.25/0.12/0.48)

- The polyurethane resin (45 g) is mixed with the blue  
presscake (57 g) in the Brabender at room temperature. The  
Brabender temperature is then increased to 190°F and mixing  
15 is resumed at 100RPM until water breaks and becomes clear.  
The mixing speed is then lowered to 40RPM and water is  
removed with a pipette. More presscake (50 g) is added,  
the mixing speed is increased to 100RPM and the above  
procedure is repeated. Then more presscake (50 g) is added  
20 and the above procedure is repeated once more. The  
temperature is then increased to 220°F and vacuum is  
applied while mixing continues. The vacuum is stopped and  
flush is checked every 3 minutes until the flush is dry (no  
more steam out). This takes about ~10 minutes. Then, the  
25 resulting solventless composition is discharged and cooled  
down to room temperature. The universal base composition  
in powder-form can then be obtained by grinding with an  
Osterizer.

VI) Universal Base Composition 6 (UB6):

UB6 is composed of the following:

- |    |       |  |
|----|-------|--|
|    | 180 g | Red pigment 52:1 presscake (25% solid)<br>(Sun Chemical Color Group)   |
| 5  | 50 g  | Polyurethane (Acid #: 42, MW <sub>w</sub> : 6000,<br>Softening point: 120°C)<br>(Toluene Diisocyanate (Bayer)/2,2-Dimethylol<br>Butanoic acid (Mitsubishi)/Dimer Diol 1075<br>(Henkel)/2-methyl-1,3-propanediol (Arco),<br>Molar ratio: 0.95/0.25/0.12/0.48) |
| 10 | 5 g   | Solsperse 24000<br>(Avecia)  |

- The polyurethane resin (50 g), Solsperse 24000 (5  
15 g) and the red presscake 52:1 (60 g) are mixed in the  
Brabender at room temperature. The Brabender temperature  
is increased to 190°F and the mixing is continued at 100RPM  
until water breaks and becomes clear. The mixing speed is  
lowered to 40RPM and water is removed with a pipette.  
20 Additional presscake (60 g) is added, the mixing speed is  
increased to 100RPM and the above procedure is repeated.  
More presscake (60 g) is then added and the above procedure  
is repeated once more. The temperature is then increased  
to 220°F and vacuum is applied while mixing continues. The  
25 vacuum is then stopped and flush is checked every 3 minutes  
until the flush is dry (no more steam out). This takes  
about ~10 minutes. Then, the resulting solventless  
composition is discharged and cooled down to room  
30 temperature. The Universal base composition in powder-form  
can then be obtained by grinding with an Osterizer.

VII) Universal Base Composition 7 (UB7):

UB7 is composed of the following:

130 g      Yellow pigment 14 presscake (38.5% solid)  
50 g      Polyurethane (Acid #: 42, MW<sub>w</sub>: 6000,  
Softening point: 120°C)  
(Toluene Diisocyanate (Bayer)/2,2-Dimethylol  
Butanoic acid (Mitsubishi)/Dimer Diol 1075  
(Henkel)/2-methyl-1,3-propanediol (Arco),  
Molar ratio: 0.95/0.25/0.12/0.48)

10                    The polyurethane resin (50 g) and the yellow  
presscake 14 (50 g) are mixed in the Brabender at room  
temperature. The Brabender temperature is increased to  
190°F and mixed at 100RPM until water breaks and becomes  
clear. The mixing speed is lowered to 40RPM and water is  
15 removed with a pipette. Additional presscake (40 g) is  
added and the mixing speed is increased to 100RPM and the  
above procedure is repeated. Then more presscake (40 g) is  
added and the above procedure is repeated once more. Then  
the temperature is increased to 220°F and vacuum is applied  
20 while mixing is continued. The vacuum is stopped and flush  
is checked every 3 minutes until the flush is dry (no more  
steam out). This takes about ~10 minutes. Then, the  
resulting solventless composition is discharged and cooled  
down to room temperature. The universal base composition  
25 in powder form is obtained by grinding with an Osterizer.

VIII) Universal Base Composition 8 (UB8):

UB8 is composed of the following:

182 g      Yellow pigment 14 presscake (38.5% solid)  
30 g      Polyurethane (Acid #: 42, MW<sub>w</sub>: 6000,  
Softening point: 120°C)  
(Toluene Diisocyanate (Bayer)/2,2-Dimethylol  
Butanoic acid (Mitsubishi)/Dimer Diol 1075  
(Henkel)/2-methyl-1,3-propanediol (Arco),  
Molar ratio: 0.95/0.25/0.12/0.48)

10            The polyurethane resin (30 g) is mixed with yellow  
presscake 14 (62 g) in the Brabender at room temperature.  
The Brabender temperature is then increased to 190°F.  
Mixing is carried out at 100RPM until water breaks and  
becomes clear. The mixing speed is then lowered to 40RPM  
15            and water is removed with a pipette. Additional presscake  
(60 g) is added and the mixing speed is increased to 100RPM  
and the above procedure is repeated. More presscake (60 g)  
is then added and the above procedure is repeated once  
more. Then, the temperature is increased to 220°F and  
20            vacuum is applied while mixing continues. Vacuum is  
stopped and flush is checked every 3 minutes until the  
flush is dry (no more steam out). This takes about ~10  
minutes. The resulting solventless composition is  
discharged and cooled down to room temperature. The  
25            universal base composition in powder form is then obtained  
by grinding with an Osterizer.

5  
10  
15  
20

60 g      White pigment  $\text{TiO}_2$   
            (Dupont)

The above polyurethane resin (40 g) is added into the steam-heated Brabender at 100°C and mixed at low speed (~20RPM) until all the resin is melted. The White pigment TiO<sub>2</sub> (60 g) is slowly added in a period of 30 minutes while mixing. The mixing is continued at 100RPM for another hour after which mixing is stopped and the resulting solventless composition mixture is discharged and cooled down. The universal base composition in powder form is then obtained by grinding with an Osterizer.

UB10 is composed of the following:

45 g Polyurethane (Acid #: 45, MW<sub>w</sub>: 6000,  
Softening point: 107°C)

(Toluene Diisocyanate (Bayer)/2,2-Dimethylol  
Butanoic acid (Mitsubishi)/Dimer Diol 1075  
(Henkel)/2-methyl-1,3-propanediol (Arco),  
Molar ratio: 0.95/0.25/0.02/0.58)

The polyurethane resin (45 g) is mixed with blue presscake (57 g) in the Brabender at room temperature. The Brabender temperature is then increased to 190°F. Mixing is then carried out at 100RPM until water breaks and becomes clear. The mixing speed is then lowered to 40RPM and water is removed with a pipette. Additional presscake (50 g) is added and the mixing speed is increased to 100RPM and the above procedure is repeated. More presscake (50 g) is added and the above procedure is repeated once more. The temperature is increased to 220°F and vacuum is applied while mixing continues. Vacuum is then stopped and flush is checked every 3 minutes until the flush is dry (no more steam out). This takes about ~10 minutes. Then, the resulting solventless composition is discharged and cooled down to room temperature. The universal base composition in powder form is then obtained by grinding with an Osterizer.

XI) Universal Base Composition 11 (UB11):

UB12 is composed of the following:

20	157 g	Phthalo blue pigment 15:4 presscake (35% solid) (Sun Chemical Color Group)
	45 g	Polyamide (Acid #: 41, MW <sub>w</sub> : 6000, Softening point: 143°C)
25		(Azelaic acid (Emerox 1144, Dock)/Diacid 1550 (Westvaco)/Isophoronediamine (Aldrich), Molar ratio: 0.49/0.12/0.53)

The polyamide resin (45 g) is mixed with blue presscake (57 g) in the Brabender a room temperature. The



temperature of the Brabender is then increased to 190°F. Mixing is then carried out at 100RPM until water breaks and becomes clear. The mixing speed is lowered to 40RPM and water is removed with a pipette. Additional presscake (50 g) is then added and the mixing speed is increased to 100RPM and the above procedure is repeated. More presscake (50 g) is then added and the above procedure is repeated once more. The temperature is increased to 220°F and vacuum is applied while mixing continues. Vacuum is then stopped and flush is checked every 3 minutes until the flush is dry (no more steam out). This takes about ~10 minutes. The resulting solventless composition is discharged and cooled down to room temperature. The universal base composition in powder form is then obtained by grinding with an Osterizer.

**Example 2 - Preparation of Liquid Dispersions from Universal Bases**

Water or solvent-based dispersions were prepared by adding ammoniacal water or solvent into the above solventless bases, followed by shaking with the Red-devil Paint Shaker or mixing by high speed mixer until the solventless bases were fully dissolved.

**I) Preparation of water-based dispersions:**

**Dispersion 1w:**

UB1 (40 g) was added into ammoniacal water (60 g, 3% NH<sub>4</sub>OH). The mixture was shaken with Red-devil Paint shaker for 2 hours. The grind was checked and a "0" reading on

the NPIRI grind gage indicates the base is fully dissolved and a good dispersion is achieved.

**Dispersions 2w-11w (w indicates water-based):**

UBs 2-10 were dissolved using the same procedure as  
5 Dispersion 1w.

UBs 2-9 were fully dissolved. However, UB10 is not dissolvable in ammoniacal water. The total weight of the hydrophobic and hydrophilic monomers for the resin used in  
10 UB10 is 18.2% of the total weight of the resin (see Table 2), which is less than the desired minimum of 20%.

UB11 is not dissolvable in ammoniacal water. The weight ratio of the hydrophobic monomer to hydrophilic monomer for the resin used in UB11 is 15.7 (see Table 2) which is out of the desired range of 1/5 to 5.

15 **II) Preparation of solvent-based dispersions:**

**Dispersion 1s (s indicates solvent based):**

UB1 (50 g) was added into the solvent blend n-propanol/n-propyl acetate (50 g, 50/50 blend) and mixed with high-speed mixer for 20 minutes. The grind was  
20 checked and a "0" reading on NPIRI grind gage indicates the base is fully dissolved and a good dispersion is achieved.

**Dispersions 2s-10s:**

UBs 2-10 were dissolved using the same procedure as Dispersion 1s.

UBs 2-9 were fully dissolved. However, UB10 is not dissolvable. The total weight of the hydrophobic and hydrophilic monomers for the resin used in UB10 is 18.2% of the total weight of the resin (see Table 2), which is less  
5 than the desired minimum of 20%.

UB 11 is fully dissolved, but the dispersion based on it is ~40% weaker than UB5, that means the polyamide used in UB11 is not an effective pigment dispersant. Also, UB11 is not dissolvable in ammoniacal water. So UB11 is not  
10 dissolvable in both water and solvent. The weight ratio of the hydrophobic monomer to hydrophilic monomer for the resin used in UB11 is 15.7 (see Table 2), which is out of the desired range of 1/5 to 5.

#### Particle Size and Distribution

15 Particle size and distribution was characterized by Microtrac Particle Size Analyzer (light-scattering technique) for the above liquid dispersions based on the solventless bases, and traditional commercial dispersions. The dispersions based on solventless bases possess smaller  
20 particle size and narrower size distribution compared to the traditional commercial dispersions, as shown in Table 1. Smaller particle size can result in better color strength, gloss and transparency of the final ink films.

**Table 1**  
**Comparison in Particle Size and Distribution**

	Mean particle size ( $\mu\text{m}$ )	Standard deviation
Dispersion 1w	0.19	0.07
Dispersion 2w	0.17	0.07
Dispersion 3w	0.15	0.06
AX <sup>TM</sup> blue base*	0.35	0.31
Dispersion 5s	0.28	0.13
ULTRABOND <sup>TM</sup> Blue**	0.31	0.18
ROTOMAX <sup>TM</sup> Blue**	0.90	0.55
Dispersion 6s	0.36	0.12
ULTRABOND <sup>TM</sup> Red**	0.53	0.28
ROTOMAX <sup>TM</sup> Red**	0.99	0.64
Dispersion 8s	0.22	0.11
ULTRABOND <sup>TM</sup> yellow**	0.75	0.29
ROTOMAX <sup>TM</sup> yellow**	0.55	0.79

\* Sun Chemical Internal water-based blue base

\*\* Sun Chemical solvent-based commercial inks

The following Table 2 summarizes the properties of each resin synthesized as well as their abilities to make a universal base.

Table 2 - Summary of Properties of resins UB1-11

Resin	Hydrophilic group wt%	Hydrophobic group wt%	Acid #	Amine#	MWw	Tsoft (°C)	Universal?
UB1 (polyamide)	27.2	23.1	0	360	3500	30	YES
UB2 (polyester)	18.8	43.6	80	0	5000	85	YES
UB3 (polyurethane)	17.9	11.7	69	0	5800	115	YES
UB4 (acrylics)	22.9	77.1	238	0	1700	105	YES
UB5 - UB9 (polyurethane)	12.2	20.7	42	0	6000	120	YES
UB10 (polyurethane)	14.1	4.0	45	0	6000	107	NO
UB11 (polyamide)	6.0	94.0	41	0	6000	143	NO

**Example 3 - Ink Formulation and Performance**

Water or solvent-based surface/laminating inks were prepared by letting down solventless universal colorants with varnishes as indicated below.

**Ink 1:** A solvent-based gravure laminating ink is composed of the following

Universal base UB3	22.0
ROTOMAX™ varnish	10.0
n-propanol	22.0
n-propyl acetate	<u>46.0</u>
	100.0

UB3 (22 g) was added to a solvent blend containing n-propanol ( 22 g) and n-propyl acetate (22 g) and shaken in Red-devil Paint Shaker for 1 hour. ROTOMAX™ varnish (10 g) and n-propyl acetate (24 g) were then added to the resulting dispersion and mixed with lab mixer for 15 minutes resulting in Ink 1.

**Ink 2:** A water-based flexo laminating ink is composed of the following:

	Universal base UB3	32.0
5	DPF426™ Letdown Varnish	13.0
	Water	49.5
	n-propanol	3.0
	Surfynol 104PA	1.0
	Ammonium Hydroxide	<u>1.5</u>
10		100.0

UB3 (32 g) was added to a mixture of water (49.5 g), n-propanol ( 3 g) and Ammonium Hydroxide (1.5 g) and shaken in Red-devil Paint Shaker for 1 hour. Letdown Varnish (13 g) and surfynol 104PA ( 1 g) were then added to the resulting dispersion and mixed with lab mixer for 15 minutes resulting in Ink 2.

**Ink 3:** A solvent-based flexo surface ink is composed of the following:

	Universal base UB3	18.0
20	SUNTEX™ Varnish TV93-5467	33.0
	n-propanol	16.0
	n-propyl acetate	<u>33.0</u>
		100.0

UB3 (18 g) was added to a mixture that contains n-propanol (16 g, n-propyl acetate (33 g) and SUNTEX™ TV93-5467 (33 g) and shaken in Red-devil Paint Shaker for 1 hour resulting in Ink 3.

**Ink 4:** A water-based flexo surface ink is composed of the following:

	Universal base UB3	30.0
	HYDROPOLY™ varnish TV88-3131	22.0
5	Water	42.5
	n-propanol	3.0
	Surfynol 104PA	1.0
	Ammonium Hydroxide	<u>1.5</u>
		100.0

10 UB3 ( 30 g) was added to a mixture of water (42.5 g),  
n-propanol ( 3 g) and ammonia hydroxide ( 1.5 ) and shaken  
in Red-devil Paint Shaker for 1 hour. Then HYDROPOLY™  
Varnish TV88-3131 (22 g) and Surfynol 104PA ( 1 g) were  
15 added to the resulting dispersion and mixed with lab mixer  
for 15 minutes resulting in Ink 4.

**Ink 5:** A solvent-based gravure blue laminating ink is composed of the following:

	Polyurethane Solution (940-1007)	24.0
	SS NC Varnish (3-V-7)	3.0
20	Syloid 161 (18-321)	1.0
	Universal Base UB5	18.6
	Water	2.0
	Ethanol	7.0
	n-propyl acetate	<u>44.4</u>
25		100.0

A varnish was prepared by mixing n-propyl acetate (44.4 g), ethanol (7 g), water ( 2 g), Syloid 161 (1 g), SS NC Varnish ( 3 g) and Polyurethane solution 940-1007 (24 g). UB5 ( 18.6 g) was then added into the above varnish,  
5 and mixed with high speed mixer at 3000RPM for 20 minutes resulting in Ink 5.

**Ink 6:** A solvent-based flexo blue laminating ink is composed of the following:

	Universal Base UB5	30.0
10	Polyurethane solution 940-1007	31.3
	Polyurethane solution 940-1	5.0
	Tyzor GBA	2.0
	Syloid 161	1.0
	n-propanol	25.7
15	n-propyl acetate	2.5
	ethanol	<u>2.5</u>
		100.0

A varnish was prepared by mixing n-propanol (25.7 g), n-propyl acetate (2.5 g), ethanol (2.5 g), Syloid 161 (1 g), Tyzor GBA (2 g), Polyurethane 940-1 ( 5 g) and Polyurethane 940-1007 (31.3 g). UB5 ( 30 g) was then added  
20 into the above varnish and mixed with high-speed mixer at 3000RPM for 20 minutes resulting in Ink 6.



**Ink 7:** A solvent-based gravure red laminating ink is composed of the following:

	Polyurethane Solution (940-1007)	20.0
	Tyzor GBA Organic Titanate	2.0
5	Syloid 161 (18-321)	1.4
	Universal Base UB6	21.0
	Water	1.9
	Ethanol	21.3
	n-propyl acetate	<u>32.4</u>
10		100.0

A varnish was prepared by mixing n-propyl acetate (32.4 g), ethanol (21.3 g), water (1.9 g), syloid 161 (1.4 g), Tyzor GBA Organic Titanate (2 g) and Polyurethane solution 940-1007 (20 g). UB6 (21 g) was then added into the above varnish and mixed with high speed mixer at 3000RPM for 20 minutes resulting in Ink 7.

**Ink 8:** A solvent-based flexo red laminating ink is composed of the following:

	Universal Base UB6	33.3
20	Sun Internal Polyurethane 94-1007	29.3
	Sun Internal Polyurethane 940-1	2.2
	Tyzor GBA	2.0
	Syloid 161	1.0
	n-propanol	20.0
25	n-propyl acetate	11.1
	Ethanol	<u>1.1</u>
		100.0

A varnish was prepared by mixing n-propanol (20 g), n-propyl acetate (11.1 g), ethanol (1.1 g), Syloid 161 (1 g), Tyzor GBA (2 g), Polyurethane 940-1 (2.2 g) and Polyurethane 940-1007 (29.3 g). UB6 (33.3 g) was then  
5 added into the above varnish and mixed with high speed mixer at 3000RPM for 20 minutes resulting in Ink 8.

The performance of these inks was compared to the corresponding commercial inks according to the following procedures. Briefly, drawdowns of experimental and  
10 standard inks were made side by side on various films with a 165 anilox handproofer, dried at 80°C for 10 seconds. Then, the following tests were performed:

Crinkle resistance: The film with the side by side drawdown was held with both hands and then crinkled in a  
15 rotating motion. The ink film was then observed for damages. This test examines flexibility of the ink films.

Water/ammonia resistance: A drop of water or ammonical water (pH=9.0) was put simultaneously on the experimental and standard ink films, and then wiped off in 10 seconds  
20 with a kimwipe. The print and kimwipe were observed for ink removal.

610 tape adhesion: With firm pressure a 610 tape was adhered on the ink film in the cross direction. After 5 seconds, the print was held with one hand and quickly the  
25 tape was pulled off the print at a 45 degree angle to the prints. The print was then observed for ink removal.

Scratch resistance: The side by side print was scratched with fingernail in a cross direction. The ink film was observed for damage.

5 Gloss: The ink film gloss was measured with BYK Gardner Glossmeter (Model 4520).

Color Strength: The color strength was measured with DataColor SF600Plus Spectrophotometer.

Transparency: The side by side print for was visually observed for transparency comparison.

10 Resolubility: Side by side drawdowns were made on the NPIRI Grind Gage for the standard and experimental inks and allowed to dry. A drop of PH9 ammonical water was put simultaneously (solvent blend used in the ink in case of solvent-based ink) over the two ink films. The ink was  
15 observed for resolubilization. The test examines the ability of the dry ink to resolubilize in the presence of solvent. An ink with unacceptable resolubility will dry on the cylinder or printing plate thereby hurting ink printability.

20 Extrusion Lamination Bond Strength: Side by side prints on appropriate films were made with 165 anilox handproofer and dried at 80°C for 10 seconds. A thin layer of primer was applied over the print with a 360-anilox handproofer and then dried at 80°C for 10 seconds. A polyethylene film was  
25 then laminated over the print with a Hot Roll Laminator at

300°F. Then, the bond strength was determined by pulling the laminated structure with Instron Tensile Tester. This test examines the adhesion and cohesion of the laminated inks.

- 5     Adhesive Lamination Bond Strength: Side by side prints on appropriate films were made with 165 anilox handproofer and dried at 80°C for 10 seconds. A thin layer of adhesive was then applied over the print with a 360-anilox handproofer and dried at 80°C for 10 seconds. A polyethylene film was
- 10    laminated over the print with a Hot Roll Laminator at 150°F. The bond strength was determined by pulling the laminated structure with Instron Tensile Tester. This test examines the adhesion and cohesion of the laminated inks.

- 15             The results of the performance of these inks are shown in Tables 3-10. Due to the fine particle size and narrow size distribution, the inks based on the solventless universal colorants possess superior gloss, color strength and transparency compared to the corresponding commercial inks. In addition, these inks possess good printability,
- 20    adhesion, laminating bond strength and other resistance properties.

**Table 3**  
**Comparison of Ink 1 with Commercial ROTOMAX™ Blue**  
**(Solvent-based Gravure Laminating Ink)**

Properties		ROTOMAX™ Blue	Ink 1
Crinkle resistance		Standard	Equal
610 Tape resistance		Standard	Equal
Scratch resistance		Standard	Slightly worse
Resolubility		Standard	Better
Extrusion bond (g/inch)	48LBT*	32	20
	50M30**	160	237
	T523*	18	127
Adhesive bond (g/inch)	48LBT*	723	42
	50M30**	797	137
	T523***	448	190
Gloss		45.8	80.8
Color Strength		100% Standard	127%
Transparency		Standard	Much better

\*corona-treated polyester; \*\*PVDC-coated polyester;  
\*\*\*corona-treated polypropylene

ROTOMAX™ blue: solvent-based gravure laminating ink based on a polyurethane and Phthalo blue pigment 15:4, Sun Chemical Corporation.

**Table 4**  
**Comparison of Ink 2 with Commercial DPF426™ Blue**  
**(Water-based Flexo Laminating Ink)**

5	Properties		DPF426™ Blue	Ink 2
	Water resistance		Standard	Equal
	Crinkle resistance		Standard	Equal
	610 Tape resistance		Standard	Equal
	Scratch resistance		Standard	Equal
10	Resolubility		Standard	Better
	Extrusion bond (g/inch)	T523*	150	130
		LBW*	235	250
	15	Extrusion bond (g/inch)	T523*	350
LBW*			307	320
Gloss		50.6	92.0	
Color Strength		100% Standard	139.0%	
Transparency		Standard	Much better	

\*corona-treated Polypropylene films

20 DPF426™ blue: water-based flexo laminating ink based on an acrylic resin and Phthalo pigment blue 15:3, Sun Chemical Corporation.

Table 5  
Comparison of Ink 3 with Commercial SUNTEX™ Blue  
(Solvent-based Surface Flexo Ink)

	Properties	SUNTEX™ Blue	Ink 3
5	Water resistance	Standard	Equal
	Crinkle resistance	Standard	Equal
	610 Tape resistance	Standard	Slightly worse
	Scratch resistance	Standard	Equal
	Resolubility	Standard	Equal
10	Gloss	73.1	80.6
	Color Strength	100% Standard	105.8%
	Transparency	Standard	Equal

\*Film T-523 corona treated Polypropylene

SUNTEX™ blue: solvent-based flexo surface ink based on a polyamide and Phthalo blue pigment 15:4, Sun Chemical Corporation.

Table 6  
Comparison of Ink 4 with Commercial HYDROPOLY™ Blue  
(Water-based Surface Flexo Ink)

	Properties	HYDROPOLY™ Blue	Ink 4
5	Water resistance	Standard	Equal
	Ammonia resistance	Standard	Worse
	Crinkle resistance	Standard	Equal
	610 Tape resistance	Standard	Equal
	Scratch resistance	Standard	Equal
10	Resolubility	Standard	Better
	Gloss	63.3	79.5
	Color Strength	100% Standard	114%
	Transparency	Standard	Better

\* Film T-523 corona treated Polypropylene

15 HYDROPOLY™ blue: water-based flexo surface ink based on an acrylic resin and blue pigment 15:3, Sun Chemical Corporation.



**Table 7**  
**Comparison of Ink 5 with ROTOMAX™ Blue**  
**(Solvent-based Gravure Laminating Ink)**

Properties		ROTOMAX™ Blue	Ink 5
Crinkle resistance		Standard	Equal
610 Tape resistance		Standard	Equal
Resolubility		Standard	Better
Extrusion bond (g/inch)	48LBT*	140	320
	M813**	110	130
	T523***	40	20
Adhesive bond (g/inch)	48LBT*	450	390
	M813*	500	230
	T523***	250	320
Gloss		51.2	82.3
Color Strength		100% Standard	130%
Transparency		Standard	Better

\* corona-treated polyester; \*\* chemically treated polyester; \*\*\*corona-treated polypropylene

ROTOMAX™ blue: solvent-based gravure laminating ink based on a polyurethane and Phthalo blue pigment 15:4; Sun Chemical Corporation.

**Table 8**  
**Comparison of Ink 6 with ULTRABOND™ blue**  
**(Solvent-based Flexo Laminating Ink)**

Properties		ULTRABOND™	Ink 6
5	Crinkle resistance	Standard	Equal
	610 Tape resistance	Standard	Equal
	Resolubility	Standard	Equal
10	Extrusion bond (g/inch)	48LBT*	50
		M813**	0
		T523*	100
	Adhesive bond (g/inch)	48LBT*	250
		M813*	150
		T523**	Film tear
15	Gloss		78.4
	Color Strength		100% Standard
	Transparency		Standard

\* corona-treated polyester; \*\* chemically treated polyester; \*\*\* corona-treated polypropylene

ULTRABOND™ blue: solvent-based gravure laminating ink based on a polyamide and Phthalo blue pigment 15:4, Sun Chemical Corporation.

**Table 9**  
**Comparison of Ink 7 with ROTOMAX™ Red**  
**(Solvent-based Gravure Laminating Ink)**

Properties		ROTOMAX™	Ink 7
Crinkle resistance		Standard	Equal
610 Tape resistance		Standard	Equal
Resolubility		Standard	Equal
Extrusion bond (g/inch)	48LBT*	15	70
	M813**	25	35
	T523*	25	70
Adhesive bond (g/inch)	48LBT*	370	520
	M813*	430	420
	T523**	350	340
Gloss		53.1	91.2
Color Strength		100% Standard	126%
Transparency		Standard	Much better

\* corona-treated polyester; \*\* chemically treated polyester; \*\*\*corona-treated polypropylene

ROTOMAX™ Red: solvent-based gravure laminating ink based on a polyurethane and red pigment 52:1, Sun Chemical Corporation.

**Table 10**  
**Comparison of Ink 8 with ULTRABOND™ Red**  
**(Solvent-based flexo Laminating Ink)**

Properties		ULTRABOND™	Ink 8
Crinkle resistance		Standard	Equal
610 Tape resistance		Standard	Equal
Resolubility		Standard	Equal
Extrusion bond (g/inch)	48LBT*	120	50
	M813**	0	100
	T523*	Film tear	Film tear
Adhesive bond (g/inch)	48LBT*	Film tear	Film tear
	M813*	50	150
	T523**	Film tear	Film tear
Gloss		71.7	88.1
Color Strength		100% Standard	129%
Transparency		Standard	Better

\* corona-treated polyester; \*\* chemically treated polyester; \*\*\*corona-treated polypropylene

ULTRABOND™ blue: solvent-based flexo laminating ink based on a polyamide and red pigment 52:1, Sun Chemical Corporation.

Application of Universal Base in Ink Jet Application

The following jet ink based on the universal colorant was prepared using the following:

	Solventless colorant UB3	10.0
5	Deionized water	83.8
	Ammonia	3.0
	Surfynol 465	0.2
	Trippropylene Glycol	<u>3.0</u>
		100.0

- 10 This ink has very fine particle size and narrow size distribution comparable to a commercial blue jet ink, as shown in Table 11. The ink also exhibited excellent dispersion stability; no settlement was observed after the ink stands on the bench for over a month. The particle
- 15 size and distribution did not change at all 7 days after the ink was put in the oven at 50°C, and no settlement was observed. The above ink was jetted with an Epson 440 ink jet printer (drop on-demand technology). An ink was also formulated with an commercial ink jet dispersion DIB-2001
- 20 (Dainippon Inks and Chemicals) and jetted with same machine. The jetted prints are comparable in terms of color strength and graphics quality.

Table 11. Particle Size and Distribution  
UB Jet Ink vs. Commercial Jet Ink

	Mean Diameter	Standard Deviation
UB3 Jet Ink	0.15	0.06
UB3 Jet Ink (7 days in oven at 50°C)	0.15	0.05
DIC Commercial Jet Ink*	0.15	0.05

5

10 \* DIB 2001™ blue jet ink based on phthalo blue 15:3 pigment, Dainippon Inks & Chemicals (DIC).

The invention has been described in terms of preferred embodiments thereof, but is more broadly applicable as will be understood by those skilled in the art. The scope of the invention is only limited by the following claims.